HISTORY AND CONSTRUCTION OF THE

TAKOMA PARK SUB-STATION

REQUIREMENT FOR MEMBERSHIP IN THE

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by

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April 17, 1936

## SUMMARY

This thesis deals with the history, construction, and operation of the Takoma Park Sub-station. After a little more than two months of hard work in the winter, the sub-station was operated for the first time on March 3, 1933. Its capacity is 60,000 KW, furnished to Washington through three Westinghouse transformers, which step the voltage down from 230,000 volts on the transmission line from Safe Harbor to 13,000 to be sent to other stations in the city. The transformers are protected by lightning arresters, circuit breakers, and other safety devices, while one attendant is always on duty. In the three years of its service, this substation has proved that it is a worth while project, and will probably be enlarged in the future. All of the above details are taken up singularly separately? in the thesis and discussed with more detail.

# HISTORY AND CONSTRUCTION OF THE TAKOMA PARK SUBSTATION

## INTRODUCTION

Since the beginning of the use of electricity in Washington, the Potomac Electric Power Company, although not always under that name, has continued to expand and increase its output. For many years the power was produced wholly in one location, the Bennings station, which was adequate for the requirements of this city. In the past few years, however, this station has proved that it would not be capable of suppling the increasing demand that was being placed upon it. For this reason, as well as for the safety obtainable in seperated plants, it was decided to supplement the system with another steam plant, which was built and named The Buzzard's Point station. This was completed in 1933, and has an output of 35,000 kilowatts. The other addition to the Washington power system was the Takoma Park Sub-station, which is a transformer step-down station supplied by hydro-electric power. The remainder of this thesis is a brief, but detailed, discussion of this sub-station.

## OCCASION FOR BUILDING THE TAKOMA PARK SUB-STATION

At the time when the Potomac Electric Power Company decided to increase its output capacity by building the Buzzard's Point station, a high voltage transmission line was being constructed from the recent Safe Harbor developement on the Susquehanna River to Baltimore City. This line passed through Ellicott City, only twenty two miles from Washington. By branching off at this point and continuing a line to Washington would not only give a ready outlet to the economic power generated at Safe Harbor, but also serve the purpose of tying in the P. E. P. Co. with the great interconnected system of Pennsylvania, New Jersey, New York, and other states, Baltimore and Washington would likewise be connected directly together, which had been planned for a long time to give economy and protection to both cities. Another reason for the immediate con-

struction of this sub-station was due to the agitation at this time over a proposed hydro-electric dam at Great Falls, an the Potomac River, which would offer serious competition to the monopoly enjoyed by the Potomac Electric Power Co.

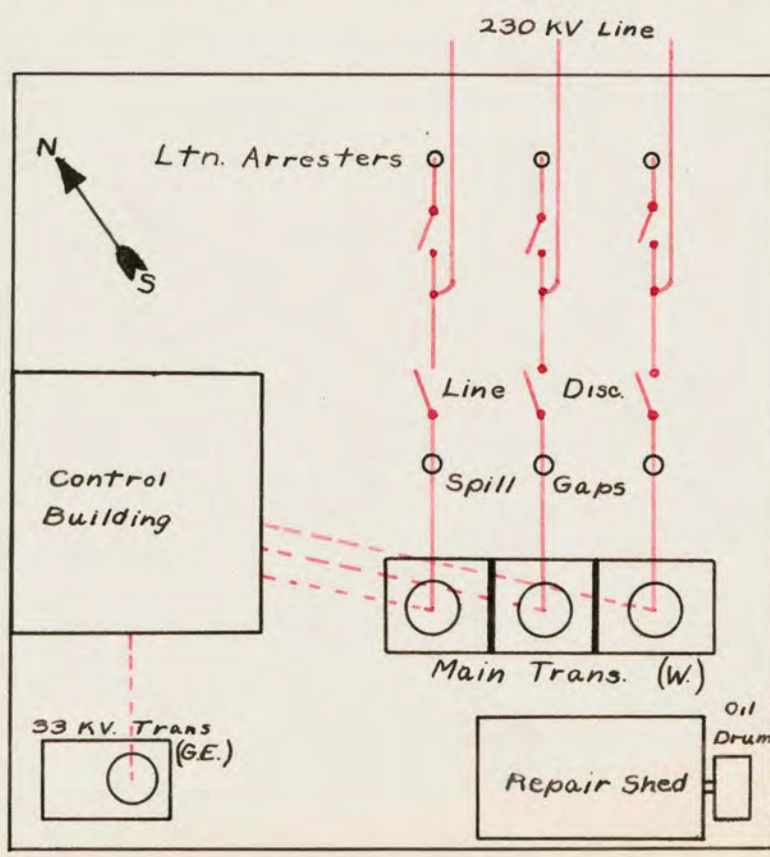
CONSTRUCTION OF THE SUB-STATION AND TRANSMISSION LINE

Having obtained the location for the substation, which is on the crest of a hill about half a mile East of Takoma Park, the contract for the construction was given out in October, 1932. Not until December of that year, however, did the work actually begin. At that time the contracting company began the construction of the building and transformer foundations. This building is a two story brick structure, about 50 by 60 feet in size. On each floor is a large room which contains the line disconnects, circuit breakers, etc. On the second floor is also the control room, while a locker, with a few spare parts, are in a small room on the first floor. The foundations for the transformers have a depth of eight feet, and around each one is a three foot layer of gravel for the purpose of draining any oil which might leak from the transformers. A concrete fire wall, one foot thick, was placed between the transformers. The transformers were delivered and assembled by the Westinghouse Manufacturing Company, each one being brought in two pieces, the bottom half and the coil together being the heaviest and weighing about 55 tons. It was necessary to lay a plank roadway from the main highway to the substation so that the large trailers carrying the transformers could get over the soft road. They were assembled by means of block and tackle. The lightning arresters, line disconnects, spill gaps, and the steel framework to support them were built by the Susquehanna Transmission Company, a company organized for the purpose of constructing the transmission lines leading from the Safe Harbor developement. This company was also building the transmission line from Ellicott City at the same time that the sub-station was being constructed. The transmission line is composed of three aluminum-steel cables, 795,000 CM each, spaced horizontally 28 feet apart. They are suspended by 9-1/2 feet insulators from steel towers,

1000 feet apart, and are 84 feet above the ground. Twenty five feet above these three are two other wires, grounded at each tower, to afford lightening protection. The P. E. P. Co. owns the transmission line and ground for a distance of about ten miles, the total cost of which was about $30,000 per mile. The sub-station itself cost $456,000, including the transformers. It was completed and put in service on March 3, 1933, and since that time no serious or prolonged interuptions have been encountered, although the transformers have been taken out of service for minor replacements several times.

## GENERAL DESCRIPTION OF THE SUB-STATION

The entire substation is enclosed in a 200 foot square. The drawing below (not drawn to scale) illustrates the relative position of the various elements. As shown, the high voltage line approaches from the north-east side of the enclosure, passes through the lightning arresters, line disconnects, and spill gaps to the transformers. At this point it is stepped down to 13,000 volts from 230,000 and passed to the control building underground. In the west corner is a smaller trans-



former which steps 10,000 KW from 13,000 back up to 33,000 volts to be sent to Bennings. In the south corner is the repair shed, which is connected to the transformers by means of a steel track with a small trolley.

THE TRANSFORMERS

In a sub-station of this kind the transformers are the most important item, and should be, as was done in this case, constructed and tested under the most exact specifications. The three main transformers, each a single phase, 60 cycle unit of 20,000 KVA capacity, were constructed by the Westinghouse Manufacturing Company. Before being accepted by the P. E. P. Co. they were tested for open and short circuit conditions, a heat run carried out, and the insulation strength tested under standard A. I. E. E. conditions. They were designed as 15,000 KVA units when self cooled, but the addition of electric fans on the air cooled radiaters boosted this capacity to 20,000 KVA. The primary winding is connected to the 230,000 transmission line through a tap changer, which permits a variation in voltage from 192,000 to 236,000 by nine different steps. The purpose of this tap changer is to keep the voltage constant and permit Baltimore to carry the reactive load, since Washington is the customer. Whenever a meter in the control building indicates that the reactive is swinging over to Washington, the attendant will, by remote control, change to the tap of next higher voltage. If the motor of the tap changer should fail, the tap could be changed by hand.

The cooling of transformers of this size is always a major problem. In each of these transformers there are 9,350 gallons of a thin oil, which circulates through the main shell and the radiaters on the side of the shell. The electric fans that cool the radiaters turn on automatically when the temperature of the oil reaches 50 degrees Centigrade. On theoutside of each transformer is a hot spot temperature recorder, and in the meter room is also an automatic recorder that tabulates the temperature every ten minutes.

As a protection against air getting into to the inside of the trans-

formers and damaging the coils, a nitrogen tank is connected to each one which keeps the shell filled with nitrogen gas to a pressure of 5 pounds per Sq. In. This pressure is released by a safety valve if it should become any greater. If the valve should stick, a pressure release diaphram will blow out if the pressure reaches 7 lbs per Sq.In. If this happens, a relay operates an oil circuit breaker and disconnects the load. Then, before the transformer can be put back in service the oil must be drained off and filtered. Another protection offered by the nitrogen is in case of fire about the transformer due to the transformer breaking, when a blanket of the gas would help to smother it.

Both the high and low side of the transformers are connected "Y", that is, each primary winding is connected between a 230,000 volt line and the ground, and each secondary winding between a 13,000 volt bus and ground. In addition there is a third winding on each transformer for the purpose of eliminating the higher harmonics in the voltage wave. These windings are connected in a closed delta between the three transformers.

Besides the transformers above there is another smaller one made by the General Electric Company with a 10,000 KVA capacity for 60 cycle, 3 phase current which steps the voltage up from 13,000 to 33,000 volts for transmission to Bennings. This transformer is also oil cooled, but without the use of fans. Since the load on it is practically constant it requires little attention or service.

## CONTROL BUILDING AND METER ROOM

After the voltage has been stepped down from 230,000 volts it passes underground into the control building that houses the oil circuit breakers, line disconnects, reactors for smoothing out any instantaneous irregularities in the current, transformers for the operation of the relays and meters, and the meters and controls. The meters are on one large board with the controls. They consist of watt hour meters furnished by both the Potomac Electric Power Company and the

Consolidated Gas and Electric Light and Power Company of Baltimore as a check on one another, numerous wattmeters and voltmeters to indicate the load and voltage of the high and low side of the transformers at any time, a synchroscope to show whether the sub-station is in phase with the Bennings plant, a temperature recorder for the three large transformers, a reactive load meter, and an automatic oscillograph, which will take pictures of the current and voltage instantly if there should be a ten percent increase or decrease in the normal voltage. A bank of 120 Exide batteries in this building supply the current for the operation of the oil circuit breakers and the tap changers. These batteries are kept floating by a small motor-generator set.

## RELAYS

The relays are for the purpose of detecting any dangerous disturbance on the line and operating the necessary safety device. For instance, to operate the oil circuit breakers, there are the overload relays and the directional ground relays. The former operate with a dangerous rise in current, while the latter will trip the circuit breaker if there is a ground on the line which is closer to this substation than to the other end of the line. These relays are set to operate from 45 to 60 cycles after the disturbance begins, which will allow for any instantaneous surge that might not be harmful. Among the other relays are the overvoltage and undervoltage relays for the oscillograph, and an oil circuit breaker relay for protection against the pressure release diaphram blowing out.

## CIRCUIT BREAKERS

The circuit breakers are of two types, oil and air, which means that the flash over from breaking the circuit is broken in oil or in air. The oil breakers are all on the 13,000 volt lines, and have a capacity of 1200 amperes. They are gang operated, which means that two or three lines are connected to one

breaker. If one line should be grounded the circuit breaker will disconnect the three lines, but the relay will indicate the grounded line and this one could be taken out of service and the others used by closing the breaker. The air circuit breaker is on the 230,000 volt line and is opened by hand after the oil breakers are opened. The flash-over caused by opening the circuit in air is often five feet long.

STATION SERVICE

The power for lighting and operating the sub-station is obtained from a line directly from the Brightwood station, and is stepped down to 220 volts. At night the sub-station is lighted by a number of 500 watt bulbs around the grounds, so that it is a blaze of light and can be seen for miles around. This power also operates the fans on the transformers, the electric hoist in the repair shed, and the motor-generator set. It is also used for heating, so that no fires are required on the premises. If this power should fail for any reason the batteries could be connected so as to light the building and run any necessary equipment during the emergency.

DANGERS AND MEASURES TO OVERCOME THEM

Besides the safety given by the circuit breakers and lightning protectors there are many other safety measures that must be taken. All the metal parts of the sub-station are grounded except, of coarse, the lines, which are well shielded from the body. Pilot lights will indicate whether the line is dead or not so that it can be worked on. Although there is little that would burn, fire extinquishers are placed at convenient points. A tall wire fence around the sub-station prevents some person from breaking in and unknowingly pulling a control handle, which might cause untold trouble.

REPAIR SHED

The repair shed consists of a tall barn like structure, made of steel framework and covered with galvanized sheet iron. On the inside there is an elec-

tric hoist which is capable of raising any part of a transformer so that it can be worked on. On one side of this shed is a large oil drum into which the oil in the transformer can be drained and filtered before replacing. A track and small trolley in front of the shed permit the transformers to be wheeled from their positions to the shed.

## DUTIES OF THE ATTENDANT

The entire personnel at the sub-station is composed of one man who is actually kept busy only a small portion of the time. Besides being constantly on alert for any indication of trouble, it is his job to tabulate the load, temperatures of the transformers, and other meter readings every hour. At his desk is a telephone that is directly connected at all times to a person of higher authority to whom he reports every hour after taking the readings. Before he makes a move, such as changing the taps of a transformer, he must obtain permission to do so.

## TIE IN WITH WASHINGTON

The accompaning blue print shows the method of connecting this sub-station with the Washington power system. Seven 500,000 CM feeders lead to the sub-station in Brightwood, where the power is distributed as needed. The connecto Brightwood is underground, whereas the 33,000 volt, 10,000 kilowatt line to Bennings is an overhead line. This line is very impractical in that it can not be used during an electrical storm, when it might be needed the most. It is seen, then, that none of the power from this sub-station is sent directly to the customer, but passes through some other station first. This gives added protection to the customer since the other station could pick up the load in case this sub-station went out. In itself this sub-station is a good protective measure in case of disability of the steam plants. Such was almost the case during the recent flood, which came dangerously near to submerging the steam plants, but had no effect upon this transformer station.